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PRE-EXPLORATION ENVIRONMENTAL RECONNAISSANCE

Tract C-b Core Drilling and Associated Groundwater Program

Prepared for

ATLANTIC RICHFIELD COMPANY
Denver, Colorado

July 15, 1974

WOODWARD-ENVICON, INC. • Environmental Consultants

OFFICES OF WOODWARD-ENVICON, INC.

1633 Old Bayshore Highway, Burlingame, California

3489 Kurtz Street, San Diego, California

4000 West Chapman Avenue, Orange, California

1373 Broad Street, Clifton, New Jersey

7330 Westview Drive, Houston, Texas

6095 Barfield Road, N.E., Altanta, Georgia

7525 East Camelback Road, Scottsdale, Arizona

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Appendix A. Resumes of Reconnaissance Team

PRE-EXPLORATION ENVIRONMENTAL RECONNAISSANCE FOR TRACT C-b CORE DRILLING AND ASSOCIATED GROUNDWATER PROGRAM

INTRODUCTION

The Exploration Plan submitted recently by the Operator (Atlantic Richfield Company) for Federal Oil Shale Tract C-b covers the proposed exploration drilling work. The Operator proposes to drill up to 17 core holes on the Tract in 1974. In addition, it is also proposed to construct a short (one-quarter mile) road leading from an existing road to site No. 13. Access to all other proposed drill sites will be along existing roads which will need improvement by gravelling or grading. Figure 1 shows the proposed drilling sites and access road locations.

Tract C-b is located in the Piceance Basin approximately 20 miles west of Rio Blanco, Colorado. A series of gulches drain Tract C-b to the Piceance Creek (see Figure 2), which in turn drains into the White River. Much of the vegetation on the ridges and slopes of Tract C-b has been recently disturbed as a result of the application of range improvement techniques.

Prior to the conduct of the core drilling and associated activities, Woodward-Envicon, Inc. conducted a five-day reconnaissance of the areas to be disturbed. This reconnaissance included observations of vegetation, wildlife, and aqautic biota and water quality.

This report presents a brief description of the vegetative, wildlife, and aqautic resources, and evaluates possible adverse impacts due to the proposed core drilling activities and access road improvements. The survey also provided preliminary information on each core drilling site prior to disturbance.

Also at the Operator's request, a brief reconnaissance of proposed air quality monitoring station sites and trailer sites was conducted. These sites are also shown in Figure 1. In addition, four previous drilling sites were also surveyed.

Woodward-Envicon acknowledges the contributions of Dr. Warren R. Keammerer and Dr. Robert E. Stoecker to the studies of vegetation and wildlife, respectively. They and the Woodward-Envicon biologists conducted the field reconnaissance and were the principal investigators for those subjects.

The resumes of all personnel involved in the reconnaissance are included in Appendix A. All laboratory work was performed by the same personnel who carried out the field work.

VEGETATION

Observations were made during a three-day reconnaissance survey of the Tract (May 13-15, 1974). Each of the proposed core drilling sites, air quality monitoring and trailer sites, and previous drilling sites was visited. The current status of the vegetation was noted, and lists of conspicuous species were made. It must be emphasized that the lists are brief and incomplete because of the early season conditions, and also because of the short observation time at each site. Therefore, the presence or absence of rare or endangered plant species is not documented. During the course of detailed investigations that will follow on Tract C-b, special attention will be given to this subject.

In addition to the field observations, a limited quantitative sampling program was conducted at six drilling sites that were representative of all sites to obtain a clearer picture of vegetation structure. Four 100-ft belt transects and line intercepts were sampled at the six sites following standard sampling techniques (Lindsey, 1955) to obtain data on shrub frequency, cover, and density. Five one-centare quadrats were sampled at each of the six sites to obtain frequency data for the ground layer herbaceous species. These samples provide only an indication of the vegetation structure, since a sample of such limited extent provides data which are highly variable. This must be considered when evaluating the data presented in the following section.

Description of the Drilling Sites

The areas in which the core drilling sites occur can be separated into five vegetation or cover types: pinyon-juniper woodland, chained pinyon-juniper, ridgetop sagebrush community, valley floor sagebrush community, and valley floor pasture. Of these, the chained pinyon-juniper is the most widespread, and ten of the drilling sites are located within this type. All of the Tract is grazed and browsed and the effects of livestock and big game can be seen in each of the types.

Pinyon-Juniper Woodland. Prior to 1966, pinyon pines (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) covered much of the Tract. In 1966, as part of a range improvement program, the Bureau of Land Management (BLM) chained approximately 3000 acres of pinyon-juniper woodland on the ridges and more gentle slopes of the Tract. Only the easternmost ridge escaped this treatment, and this is where drilling site 17 is located. Many of the trees on this ridge are small- to medium-sized, and in several places the density is great enough to form a closed canopy. A few large trees occur, however, and a pinyon pine with a 33-in. diameter is located approximately 60 yards south of the proposed drilling site. The shrub layer in this woodland is composed mostly of snowberry (*Symphoricarpos oreophilus*), but nine other shrub species add to the diversity of the site (Table 1, site 17). Eighteen species were encountered in the herb layer sample with western wheatgrass (*Agropyron smithii*), mutton grass (*Poa fendleriana*), and a cushion-forming species of *Phlox* occurring as the most common species (Table 2, site 17). A total of 29 species were observed on the site (Table 3). The average cover in the herb layer was 30 percent, which is comparable to that of the chained areas.

Chained Pinyon-Juniper. The chained areas appear devastated. The ground is strewn with dead trees, and the intervening areas are trampled as a result of livestock grazing. The species composition of these areas is very similar to the pinyon-juniper woodland understory; however, because of the disturbance, there is a larger component of annual species characteristic of grazed areas. On most of the chained sites, big sagebrush (*Artemisia tridentata*) is the most common shrub species (Table 1, sites 5, 11, and 15); however, numerous shrub species occur on these sites. It can be imagined that the chaining had a less severe impact on the shrub and herbaceous species, and they have recovered much more quickly than the trees. Most of the shrub species are tolerant of full-sun conditions, and only snowberry seems to have decreased significantly on the chained sites, where it occurs more frequently in the shelter of the downed trees

United States Department of the Interior
GEOLOGICAL SURVEY
Denver Federal Center
Denver, Colorado 80225

IN REPLY REFER TO:

July 29, 1974

Memorandum

To: W. L. Rogers, Chairman, OSEAP, Bldg. 67, DFC

From: Area Oil Shale Supervisor, Conservation Div., USGS

Subject: Report by Woodward-Envicon, Inc. for Tract C-b

Enclosed is a copy of the preliminary biological examination report for Tract C-b covering primarily drilling, monitoring, and support sites.

Copies of letter reports on Archeology examinations of these sites are available in my files should you ever have need for them.

J. W. Hager
for Peter A. Rutledge

Enclosure

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than it does in the open. Total shrub cover on these sites averaged 11 percent with cover contributed by 13 species. The herbaceous layer contained numerous species (Table 2, sites 5, 11, and 15, and Table 4). Indian ricegrass (*Oryzopsis hymenoides*), cheatgrass (*Bromus tectorum*), false dandelion (*Agoseris glauca*), and squirrel-tail grass (*Sitanion longifolium*) were some of the most common species. Cover in the herb layer averaged 21 percent.

Ridgetop Sagebrush Community. Intermixed with the original pinyon-juniper woodlands were openings in which big sagebrush was the dominant species. These were also chained as part of the BLM improvement program. The sagebrush has recovered from the treatment and now occurs as a recognizable cover type interspersed with the destroyed woodland. Big sagebrush is the dominant species (Table 1, site 6), but numerous pinyon and juniper saplings indicate possible successional trends. Total shrub cover on the sampled site was only 5 percent. Eight herbaceous species encountered in the sample had frequency values of 100 percent (Table 2, site 6) which is indicative of a rather homogeneous herb layer. A total of 24 species was recorded from the ridgetop sagebrush drilling sites (Table 5).

Valley Floor Sagebrush Community. Most of the valley areas between the ridges support rather extensive sagebrush communities. In places the sagebrush has been cleared and the valley floors serve as pastures. In most places the sagebrush is browsed even though the sites have not been cleared. Big sagebrush and winter fat (*Eurotia lanata*) were the dominant species at site 14 (Table 1). Many of the individual plants were small and very numerous (9280 total shrubs/acre). Two species of rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*), although not abundant on the sampled site, are also important on the valley bottom sites. Cheatgrass and blue grama (*Boutelous gracilis*) were the most common species in the herb layer, where a total of 13 species covered 30 percent of the ground (Table 2, site 14). In all, 16 species were observed on the two drilling sites occurring in this vegetation type (Table 6).

Valley Floor Pasture. Only one drilling site is located within this cover type (site 8). The species composition is similar to the sagebrush type discussed above, but the shrub component is greatly reduced. Twelve species were observed on this site (Table 7).

Anticipated Impacts Resulting From Core Drilling and Road Improvement

Drilling Sites. The previous disturbances from chaining and grazing which characterize the Tract greatly reduce the impacts which will result from the drilling operation. It is difficult to imagine impacts as severe as those which have already occurred on the site. The drilling sites themselves will disturb less than 2 acres on the Tract, and approximately 60 percent of this area occurs on chained pinyon-juniper sites. The impact of drilling on these sites should be negligible. Six of the remaining sites occur on either sagebrush or pasture sites which are grazed, thus reducing the impact of drilling operations. Drilling will, however, result in a small area removed from productivity for a short time. This may result in some increase in grazing pressure on other portions of the Tract. Therefore, there may be a temporary need to reduce the number of livestock allowed to graze on the Tract and/or to readjust the period of time permissible for grazing. With proper care, these sites should not be too difficult to revegetate.

The remaining site (site 17) is located in a pinyon-juniper woodland on the only unchained ridge on the Tract. Impacts on this site would include destruction of several medium-sized trees and removal of the understory. In light of the extent of chaining, the loss of a few more trees seems relatively insignificant. However, a possible alternative may be to position the drilling site in an opening in the woodland located about one-half mile north of the present site. The alternate site is covered by an open sagebrush community and, besides obviating the need to cut trees, the site would be easier to revegetate. A second alternative would be to eliminate any site on this ridge, since an impact greater

than construction of the site itself will be the improvement of the access road along the ridgetop. It is suggested that the information to be gained from a drilling site on this ridge should be carefully weighed against the impacts resulting from road improvement and site preparation.

Road Improvement. Aside from the already mentioned problem with the site 17 access road, minimal impacts will result from road improvement on the Tract. Most of the roadways are located in the chained pinyon-juniper areas, and improvement will have a negligible impact on the vegetation. If possible, it is recommended that roadsides be graded to prevent mounding of the material scraped from the roadbed.

Two interesting species (*Anemone patens* and *Clematis hirsutissima*) occur along the access road out of the West Fork of Stewart Gulch to the ridgetop where site 13 is located. Road construction along this route should be controlled so that these species are not adversely affected. (These two species are not rare in Colorado; they are abundant wildflowers. However, the location described above is the only site where these species were noted on the Tract, and for this reason they are of interest.)

Locations of Air Quality Monitoring and Trailer Sites

The air quality monitoring sites and trailer sites are located on agricultural lands, chained pinyon-juniper, and ridgetop sagebrush sites which are similar to those sites studied for preliminary quantitative information. Impacts on the vegetation will be negligible at the selected sites. No additional roadways will be needed for access to the sites.

Impact of Wastewater from Previous Drilling

Each of four previous core drilling sites on the Tract were visited to determine the extent of impact resulting from wastewater produced during the drilling operation. At each site the impact was limited to small rills which were cut into the substrate. These required considerable searching to locate, and had we not been alerted to their locations and origins, they would have been overlooked.

Summary

The exploratory drilling operation will have negligible impact on the vegetation of the Tract. Previous disturbances from BLM range improvement techniques have destroyed the natural features, thus reducing the magnitude of impact of subsequent surface modifications.

If possible, it is recommended that drilling site 17 be moved to a location approximately one-half mile north of its current position in order to minimize disturbance to the surrounding pinyon-juniper vegetation.

Impacts from air quality monitoring sites and service trailers will be negligible.

No serious environmental impacts caused by wastewater from previous drilling on the Tract were noted.

Literature Cited

Lindsey, A.A. 1955. "Testing the line-strip method against full tallies in diverse forest types." *Ecology* 36: 485-494.

WILDLIFE

Preliminary wildlife investigations were also conducted on Tract C-b from May 13 through May 15, 1974. Potential hazards to wildlife or to wildlife habitat were considered, including those caused by traffic, modification of existing roads, and disturbances around proposed drilling sites, trailer sites, and air quality stations. In the course of the field reconnaissance in these areas, conspicuous birds and mammals were identified and tracks, dens, trails, etc. were noted. Particular attention was given to the possible existence of critical habitats, important migrational routes for deer and elk, strutting grounds for sage grouse, or other rare or unusual situations of value from a wildlife standpoint. During this brief preliminary survey, no rare or endangered species were encountered. However, in the detailed investigation that will follow special attention will be given to these species.

Interesting Wildlife Areas

Few natural areas remain on the Tract C-b because of the Bureau of Land Management's extensive chaining program and the attendant grazing by cattle. The remaining natural areas include some of the lateral draws in Willow, Scandard, and Stewart gulches, some of the smaller valleys with trees and rim rock, and a ridge-top grove of pinyon-juniper where drill site No. 17 is located. These areas have potential as small refuge for non-game and game species and contain some of the only cover, nest sites, and den sites important to the more aesthetic animal species. Modification of existing roads and disturbances around drill sites should have no important deleterious effects with but one exception. Disturbance near drill site No. 17 should be minimized because this is also an important habitat for deer and all other wildlife species common to mature pinyon-juniper forests in this region. If drill site No. 17 could be relocated to the clearing approximately one-half mile to the north, less disturbance and damage to wildlife habitat would occur.

Specific Wildlife

Mule Deer and Elk. Mule deer are abundant on Tract C-b as was evident by tracks, deer pellet groups (Table 8), and the extent of shrub utilization. The four most important browse plants on Tract C-b are serviceberry, bitterbrush, mountain mahogany, and oak. These appear to be rather evenly distributed over the tract, except that oak is more abundant in the lateral draws. The distribution of the browse plants as well as the watering locations are such that little possibility exists for deer or elk being especially attracted to or dependant upon habitat near roads or drill sites.

Migrational routes on Tract C-b are most probably limited to typical "deer crossings." They are unlikely to be anything more impressive since these deer are members of the now well-known migratory deer herd of the Piceance Basin. Deer and elk do have a propensity to cross roads at certain locations, but usually because of some local topographic or vegetational feature which provides cover, green grass in early spring, hay in winter, etc. Drill site No. 14 is probably on a well-used deer crossing, and during fall and winter considerable movement across the road is likely to occur at this location.

No significant habitat destruction or other undesirable effects on deer or elk are to be anticipated from the preliminary drilling and road modification planned for Tract C-b.

Other Mammals. Coyote tracks were common along the rim rock in the lateral draws. Several species of smaller mammals were seen, including chipmunks, ground squirrels, and marmots in the lower valleys. Evidence of pocket gopher activity and woodrat and other cricetid rodent signs were seen but were not unusually common. No disturbance to small- and medium-sized mammals is to be expected from preliminary work on the Tract.

Raptors. Five species of raptors were identified, and a number of raptor nests were observed among the cliffs of Stewart and Willow gulches. One large inactive raptor nest is located approximately 200 yards west of drill site No. 8, and disturbances to nesting birds could occur if nesting and drilling coincide. Whether the nest will be active next spring, however, is unknown. However, as a precautionary measure, it is recommended that drilling at this site be carried out in late summer/early fall. No other significant impact on raptors is anticipated as a result of preliminary work on the Tract.

Other Birds. Twenty-four species of birds other than raptors were identified in the area. No strutting grounds of sage grouse were found, and it is unlikely that these game birds occur on the Tract. Bluegrouse undoubtedly occur, but none were seen. No important impacts on non-game or game birds are likely from the preliminary work on the Tract.

Summary

In summary, the only important concern from a wildlife standpoint is that appreciable disturbance in the vicinity of drill site No. 17 is likely. This could be avoided by relocating the site to the north in an existing clearing if such a relocation is compatible with the planned exploration activities.

Table 9 provides a list of birds and mammals observed by sight, sign, scat, tracks, etc. on the lease land.

WATER QUALITY AND AQUATIC BIOTA

The inventory of water quality and aquatic biota provides baseline information prior to drilling disturbances and associated activities on Tract C-b.

It would have been desirable to select sampling stations to reflect drainage upstream of Tract C-b, drainage within Tract C-b, and drainage downstream of Tract C-b. However, drainage channels upstream and within the Tract were dry during the period of reconnaissance and therefore the selected sampling stations (as shown in Figure 2) were all downstream of the Tract. Specifically, six sampling stations were located along Piceance Creek, three stations along Willow Creek, and one station in Stewart Gulch. Water in lower Stewart Gulch came from several irrigation reservoirs; however, upper Stewart Gulch was dry and consequently not sampled. Likewise, several of the gulches which drain Tract C-b were dry, and no aquatic organisms or water quality samples could be collected. These included the West Fork of Stewart Gulch, Sorghum Gulch, Cottonwood Gulch, and Scandard Gulch.

Water Quality

Water samples were analyzed to determine levels of important chemical parameters with respect to aquatic flora and fauna of Piceance, Willow, and Stewart creeks.

Water quality sampling consisted of taking one-quart water samples at three stations along Piceance Creek (P-1, P-3, and P-6), two stations on Willow Creek (W-1 and W-3), and one station in Stewart Gulch (S-1). Samples were analyzed in the field using a Hach DR-EL/2 portable test kit for the following parameters: temperature, pH, total alkalinity, carbon dioxide, specific conductance, dissolved oxygen, total hardness, total iron, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, ortho-phosphate, and turbidity.

The chemical composition of water is important since it can either limit or enhance the survival of aquatic organisms. For example, critical life stages or metabolic processes of these organisms can be affected by changes in water quality. Optimum values exist for all chemical parameters which can be used as indicators of favorable conditions for the survival of resident aquatic organisms.

The permissible range of pH for aquatic fauna depends upon a combination of factors such as temperature, dissolved oxygen, and the presence of various anions and cations. Naturally occurring pH levels are usually in the range of 6.5-8.5. Temperature is important in the regulation of metabolism, growth, and reproduction. Dissolved oxygen in amounts greater than 5 mg/ℓ is generally necessary to sustain healthy aquatic life. Specific oxygen requirements of fish vary with species, age of fish, temperature, and the concentration of other substances in the water. Carbon dioxide, a by-product of metabolism and aerobic decomposition of organic matter, can be lethal in high concentrations, but can also be beneficial to fish by lowering the pH and decreasing the un-ionized ammonia in certain waters.

Alkalinity of water defines the combined effect of several dissolved substances and conditions. Hardness results from a concentration of certain cations in water, such as calcium or magnesium. Hardness is increased by return flow from irrigation ditches and by natural accumulations of salts from contact with soil and geological formations.

Iron is an important constituent in animal diet. Concentrations in natural waters are usually buffered and are normally less than 10 mg/ℓ.

Phosphates and nitrates can occur in groundwater as a result of degradation of organic matter and leaching from agricultural fertilizer applications. Phosphate and nitrate concentrations stimulate the growth of plankton and aquatic weeds, indirectly stimulating increased fish population. Ammonia nitrogen in surface or groundwater generally results from the decomposition of nitrogenous organic matter. Large concentrations can be toxic, but the presence of carbon dioxide does reduce the toxicity.

Turbidity can be detrimental in the aquatic environment by reducing photosynthesis and primary productivity. At high concentrations the particulate matter that produces turbidity may cause death by clogging the gills of fish. It may also reduce the ability of fish to find food, and can alter the temperature regimes of a body of water.

Salinity is determined by the concentration of dissolved solids in water. The determination of specific conductance (μmhos/cm) is an acceptable indirect method to measure the dissolved solids. In natural waters the dissolved solids consist mainly of carbonates, bicarbonates, chlorides, sodium salts, and other minerals. All substances in solution exert osmotic pressure on the organisms living in it, and the aquatic life is adapted to the conditions of the ambient environment. Wide variations in the dissolved solids can have a deleterious effect on aquatic life by changing the osmotic pressure sufficiently to result in an excessive transfer of water into or out of an organism.

Results of Field Analysis. Among the series of gulches that drain Tract C-b, only Stewart Gulch and Willow Creek Gulch contained water. The water flowing from these gulches into the Piceance Creek was very hard and alkaline. Stewart Gulch water is spring fed and high in dissolved minerals, as indicated by total alkalinity of 450 mg/ℓ and a specific conductance of 1400 μMHOS/cm. Willow Creek which enters Piceance Creek at the lower end of Tract C-b drainage had water quality similar to Stewart Gulch (Table 10).

Concentrations of dissolved minerals as indicated by total hardness and specific conductance was slightly lower in Piceance Creek than in the water from Stewart Gulch or Willow Creek Gulch. This may be due to the diluting influence of surface and irrigation waters on dissolved minerals in Piceance Creek (May, 1970).

Generally speaking, the waters that drained Tract C-b were hard and alkaline in quality. Actual values for water quality parameters can be extremely variable and would reflect local conditions regulating the flow

of surface and groundwater in the area. Rainfall, livestock, and irrigation activities all can cause fluctuations in the values of the water quality parameters that were measured.

Heavy livestock utilization of pastures in the Piceance Creek Valley probably results in a certain amount of nutrient material being leached into Piceance Creek by irrigation runoff and other surface water. The small amounts of ammonia nitrogen, nitrate nitrogen, and ortho-phosphate present in the water sampled indicate that agricultural activity does have some influence on the water quality.

Aquatic Biota

Benthic Investigations. Benthic invertebrate samples were taken at six sites on Piceance Creek (P_1 - P_6), three sites on Willow Creek (W_1 - W_3), and one site in Stewart Gulch (S_1). Organisms were collected by vigorously disturbing the stream substrate for a standard 30-second time period, thus allowing dislodged insects to be caught on a 2 ft x 2 ft screen held downstream. Samples were preserved in 70 percent isopropyl alcohol and transported to the lab for identification as to Order. Table 11 lists aquatic insects collected for each sample site and gives counts of organisms by Order during the study.

Aquatic insect fauna collected during a short time period at a given site does not indicate all of the different species which utilize the same habitat over a broad time period. Variation in life cycles, number of generations per year, and climatic seasonal changes all contribute to fluctuation in abundance and diversity of a specific aquatic insect at a given time. Collections of benthic invertebrates made during reconnaissance sampling in the Tract C-b drainage are useful as general indicators of the quality of aquatic habitat in the region relative to reproduction of aquatic fauna. Tract C-b drainage area is in an intensively used agricultural area, used primarily for cattle grazing. The large number of organisms collected at some sample sites in Tract C-b drainage (Table 11) indicates a very good production potential for aquatic

invertebrates. It is possible that dynamics of aquatic fauna populations found in the Tract C-b drainage are to some degree influenced by the presence of livestock in and around the streams. This effect, if any, is not presently documented for this area, and was not researched during this reconnaissance.

Fish Investigations. Fish sampling was conducted in Piceance, Willow, and Stewart creeks by means of a battery-powered backpack shocker (Model BP-2, Coffelt Electronics Company, Inc., Denver). All fish collected were measured for total length and scales were taken from gamefish. Fish scales will be examined for indications of age; the data will be used in future population studies. Fish were returned to the stream immediately after sampling, except for non-game representatives that were kept for positive laboratory identification. Three species of gamefish (rainbow, brook, and brown trout) and two species of non-game fish (bluehead sucker and speckled dace) were collected from Piceance Creek. Willow Creek (Station W-1) and Stewart Creek (Station S-1) contained bluehead suckers only. No fish were collected from Stations W-1 and W-3 on Willow Creek. Scandard Gulch, Cottonwood Gulch, Sorghum Gulch, and the West and Middle Forks of Stewart Gulch contained no water and were not sampled. Of 109 total fish collected during reconnaissance sampling (Table 12), there were 57 bluehead suckers, 30 speckled dace, 19 brook trout, 2 brown trout, and 1 rainbow trout. In addition, one trout larva was collected during benthic sampling at Station S-1, but positive species identification was not possible because of mutilation during capture.

Resting, spawning, or nursery potential for gamefish in Piceance, Willow and Stewart creeks is believed minimal.

Sample sites were generally characterized by nearly parallel stream channels, even flows, shallow uniform depths, and heavily silted fine gravel substrates. These factors along with the relative scarcity of pools or stream barriers (large rubble or logs) made much of the habitat

sampled highly unsuitable for a large gamefish population. This is especially true of Willow and Stewart creeks, which contained no game species at all. However, gamefish that were collected in Piceance Creek during reconnaissance sampling appeared healthy and in good shape. It is evident that the aquatic environments of Piceance, Willow and Stewart creeks favor less desirable but more highly adaptable non-game species such as the bluehead sucker and speckled dace. In a 2-year investigation of Piceance Creek, May (1970) found flannelmouth sucker, mottled sculpin, bonytail chub, black bullhead, red shiner, and mountain whitefish in addition to the species sampled by Woodward-Envicon, Inc. during this sampling in the Tract C-b drainage. However, Mr. May's investigations were more extensive and covered a significantly larger area than did the Tract C-b sampling, and it is expected his collections more nearly reflect the wide range of fish fauna existing in the varied habitats of the entire Piceance Creek.

The five-day fish investigations in the Tract C-b drainage were significantly hindered by high turbidity levels as a result of spring snow melt in the Piceance Basin. It was difficult to see the fish, especially smaller forms which had been stunned with the backpacker shocker. It is certain that bottom-hugging forms such as sculpins were shocked but never seen and hence never collected. A repeat sample effort at a low-water period, preferably late summer, would allow a more efficient collection of fish samples in the Tract C-b drainage, and eliminate the turbidity problem.

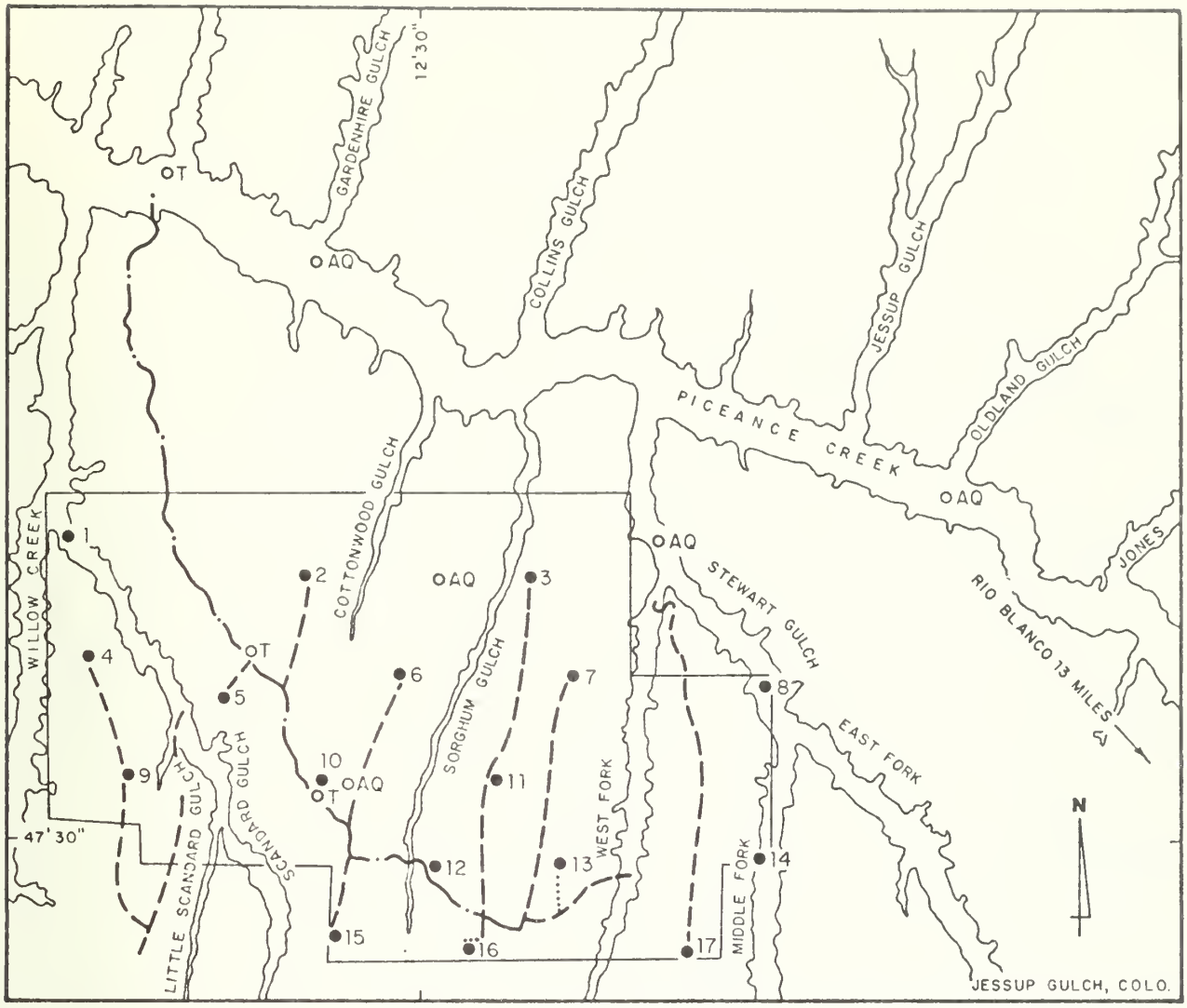
Periphyton. Due to cold water temperatures and high, silt-laden spring flows, periphyton growth in Piceance, Willow, and lower Stewart creeks was nearly non-existent. The periphyton samples were mixed with a great deal of detritus from the stream bottoms.

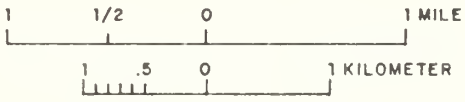
Analysis of the samples indicated the presence of clean water types of algae. The three streams sampled adjacent to Tract C-b had similar populations of periphyton. Diatoms predominated, while only one genus

of filamentous green algae (Chlorophyta) and one genus of filamentous blue-green algae (Cyanophyta) were found. In addition, Stewart Creek and Willow Creek contained submerged vascular plants. Higher plants were absent from Piceance Creek, probably due to the turbulent flow and silt load that was carried by the creek at the time of sampling. The periphyton found are listed in Table 13.

References

1. E.P.A., National Environmental Research Center Analytical Quality Control Lab. 1971. *Methods for Chemical Analysis of Water and Wastes*. Cincinnati, Ohio.
2. American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*. Washington, D.C.
3. May, Bruce. 1970. *Biota and Chemistry of Piceance Creek*. Masters Thesis, Colorado State University. p. 67.





● Proposed core drilling sites

OT Trailer sites

OAQ Air quality stations

Roads to be gravelled (approximate location)

Roads to be graded (approximate location)

New roads to be built (approximate location)

Tract C-b boundary

Figure 1. Location of proposed drilling, air quality monitoring and trailer sites

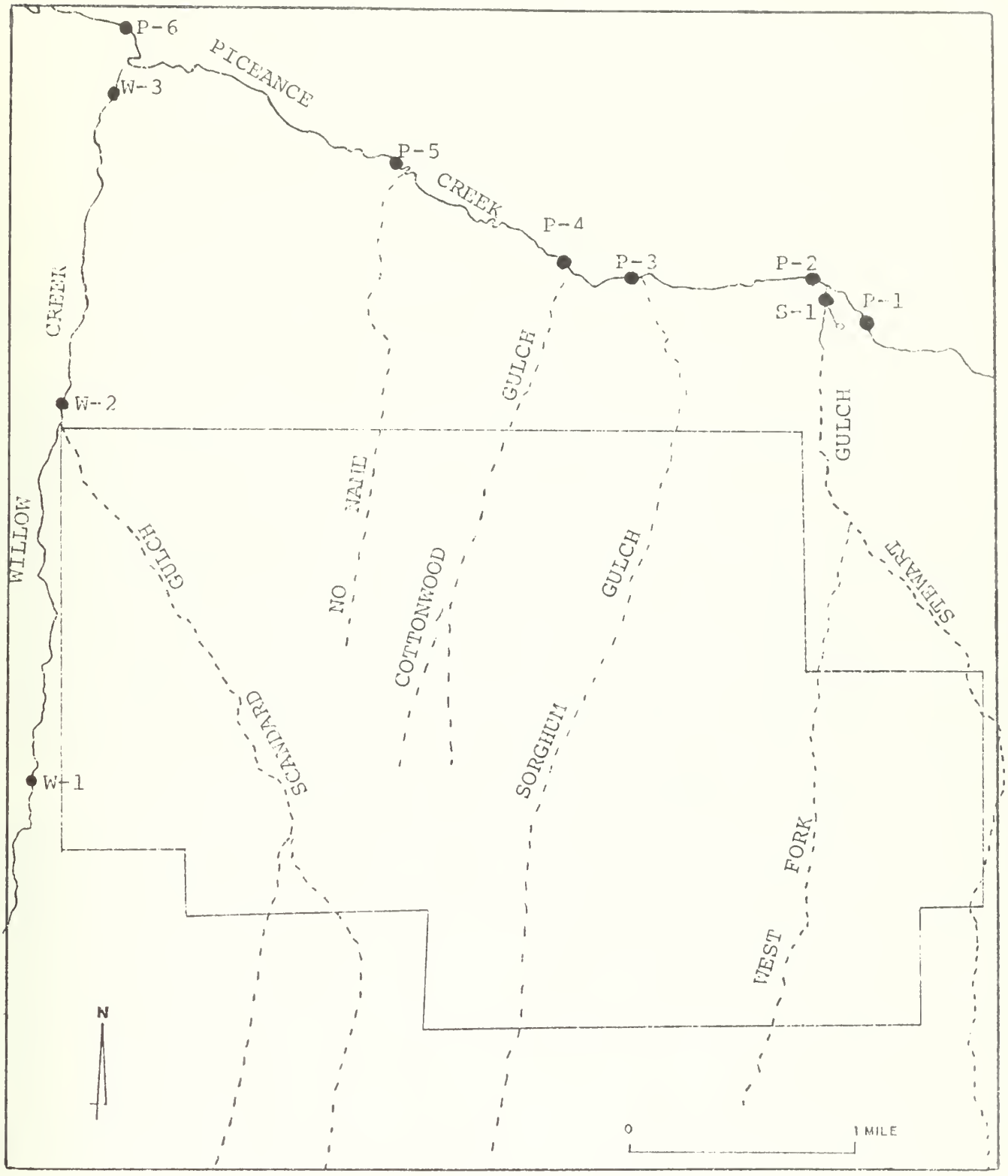


Figure 2. Aquatic sampling stations for Tract C-b predisturbance investigations

Table 1. FREQUENCY, COVER, AND DENSITY VALUES FOR SHRUB SPECIES ENCOUNTERED IN THE LINE-STRIP SAMPLES. VALUES ARE BASED ON FOUR 100-FT LINE-STRINGS AT EACH DRILLING SITE.

Species	Drilling Site Number 5	6	11	14	15	17
	% Frequency					
Amelanchier sp.	---	---	75	---	100	100
Artemisia tridentata	100	100	100	100	25	50
Cercocarpus montanus	50	---	---	---	100	100
Chrysothamnus nauseosus	---	---	25	100	75	75
Chrysothamnus viscidiflorus	---	75	100	50	25	---
Eurotia lanata	---	---	---	100	25	---
Juniperus osteosperma (tree)	---	---	---	---	---	25
J. osteosperma (sapling)	100	50	75	---	75	75
Opuntia polyacantha	75	---	25	---	25	---
Pinus edulis (tree)	---	---	---	---	25	---
Pinus edulis (sapling)	25	25	100	---	100	100
Purshia tridentata	50	---	25	---	25	100
Quercus gambelii	---	---	---	---	50	25
Symphoricarpos oreophilus	100	---	50	---	100	100
Tetradymia canescens	---	---	---	---	25	---
	% Cover					
Amelanchier sp.	--	--	<1	--	1	1
Artemisia tridentata	5	5	4	10	<1	2
Cercocarpus montanus	<1	--	--	--	4	<1
Chrysothamnus nauseosus	--	--	<1	<1	<1	<1
Chrysothamnus viscidiflorus	--	<1	<1	<1	<1	--
Eurotia lanata	--	--	--	1	<1	--
Juniperus osteosperma (tree)	--	--	--	--	--	3*
J. osteosperma (sapling)	<1	<1	1	--	2	3
Opuntia polyacantha	<1	--	<1	--	<1	--
Pinus edulis (tree)	--	--	--	--	7*	8*
Pinus edulis (sapling)	<1	<1	1	--	3	2
Purshia tridentata	<1	--	<1	--	<1	1
Quercus gambelii	--	--	--	--	5	2
Symphoricarpos oreophilus	3	--	<1	--	2	9
Tetradymia canescens	--	--	--	--	<1	--
**Total	9	5	7	11	18	20

Table 1. (Continued)

Species	Drilling Site Number 5	6	11	14	15	17
	Density (Individuals/Acre)					
Amelanchier sp.	---	---	160	---	820	490
Artemisia tridentata	2040	3760	2020	5350	20	550
Cercocarpus montanus	160	---	---	---	930	270
Chrysothamnus nauseosus	---	---	50	330	130	160
Chrysothamnus viscidiflorus	---	350	270	110	80	---
Eurotia lanata	---	---	---	3490	20	---
Juniperus osteosperma (tree)	---	---	---	---	---	20
J. osteosperma (sapling)	130	110	130	---	130	160
Opuntia polyacantha	80	---	20	---	50	---
Pinus edulis (tree)	---	---	---	---	20	---
Pinus edulis (sapling)	80	20	270	---	510	180
Purshia tridentata	50	---	50	---	20	350
Quercus gambelii	---	---	---	---	780	110
Symphoricarpos oreophilus	1090	---	110	---	1090	3380
Tetradymia canescens	---	---	---	---	50	---
Number of Species	7	4	9	4	13	10

*Canopy cover

**For cover, 4 times (<1) = 1%

Table 2. FREQUENCY VALUES FOR HERBACEOUS SPECIES ENCOUNTERED IN THE QUADRAT SAMPLES (values based on 5 one-centare quadrats)

Species	Percent Frequency Drilling Site Number					
	5	6	11	14	15	17
Agoseris glauca	40	100	80	--	20	60
Agropyron smithii	20	100	40	60	--	100
Agropyron sp.	--	--	--	--	20	--
Antennaria parvifolia	--	100	20	--	20	--
Antennaria rosea	--	--	--	--	--	60
Arabis sp.	--	20	20	--	--	20
Artemisia frigida	--	--	--	20	--	--
Astragalus spp.	20	--	60	--	20	40
Bouteloua gracilis	--	--	--	80	--	--
Bromus tectorum	40	--	60	100	--	--
Calochortus sp.	--	100	40	--	--	20
Carex pennsylvannica (?)	--	80	40	--	--	--
Carex sp.	--	--	--	--	--	40
Comandra umbellata	--	--	80	--	--	20
Cymopterus sp. (?)	--	--	--	--	40	20
Delphinium nelsoni	--	--	--	--	--	20
Descurainia pinnata	--	--	--	20	--	--
Erigeron sp.	--	60	20	--	--	20
Gutierrezia sp. (?)	--	--	--	--	80	--
Haplopappus nutallii	--	--	--	--	20	--
Lappula redowskii	20	--	60	80	--	60
Lepidium montanum	--	--	--	60	--	--
Lomatium sp. (?)	--	--	20	--	--	--
Lupinus sp.	--	--	40	--	--	--
Oryzopsis hymenoides	60	--	--	--	80	--
Phacelia sp.	20	--	--	--	--	--
Phlox hoodii	20	100	60	40	80	80
Phlox longifolia	--	80	40	--	20	40
Pinus edulis (seedling)	20	--	--	--	--	--
Poa fendleriana	60	20	--	--	--	100
Poa spp.	--	100	100	--	20	--
Senecio sp.	20	--	--	--	--	20
Sisymbrium altissimum	--	--	--	20	--	--
Sitanion longifolium	80	--	40	--	60	--
Sphaeralcea coccinea	--	100	--	20	20	--
Taraxacum officinale	20	--	40	40	--	20
Tragopogon dubius	20	--	--	--	--	--
Zygadenus venenosus	--	--	40	--	--	20
Unknown Cruciferae	--	--	60	--	--	--
Unknown Gramineae	--	--	--	40	--	--
Unknown Scrophulariaceae	60	--	--	--	--	--
Unknown Umbelliferae	--	100	--	--	--	--
Unknown forb seedling	--	--	--	20	--	--
Mosses	--	20	20	40	20	40
Average herbaceous cover	23%	23%	20%	30%	21%	30%
Number of species	15	13	20	13	13	18

Table 3. SPECIES OBSERVED IN THE PINYON-JUNIPER WOODLAND (DRILLING SITE 17)

Agoseris glauca	*Delphinium nelsoni*
Agropyron smithii	*Erigeron* sp.
Amelanchier alnifolia (?)	*Juniperus osteosperma*
Antennaria rosea	*Lappula redowskii*
Arabis sp.	*Opuntia polyacantha*
Artemisia tridentata	*Phlox hoodii*
Astragalus spp.	*Phlox longifolia*
Balsamorhiza sagittata	*Pinus edulis*
Calochortus sp.	*Poa fendleriana*
Carex sp.	*Purshia tridentata*
Cercocarpus montanus	*Quercus gambelii*
Chrysothamnus nauseosus	*Symphoricarpos oreophilus*
Comandra umbellata	*Taraxacum officinale*
Cymopterus sp.	*Zygadenus venenosus*
	Senecio sp.

Table 4. SPECIES OBSERVED ON CHAINED PINYON-JUNIPER SITES (DRILLING SITES 2, 3, 4, 5, 7, 9, 11, 12, 13, and 15)

Agoseris glauca	*Comandra umbellata*
Agropyron smithii	*Cryptantha* sp.
Amelanchier alnifolia (?)	*Cymopterus montanus* (?)
Androsace septentrionalis	*Delphinium nelsoni*
Antennaria parvifolia	*Erigeron* sp.
Antennaria rosea	*Eurotia lanata*
Arabis sp.	*Haplopappus nuttallii*
Artemisia dracunculus	*Ipomopsis aggregata*
Artemisia tridentata	*Juniperus osteosperma* (sapling)
Astragalus (5 species)	*Lappula redowskii*
Balsamorhiza sagitatta	*Lomatium* sp. (?)
Bouteloua gracilis	*Lupinus* sp.
Bromus tectorum	*Opuntia polyacantha*
Calochortus sp.	*Oryzopsis hymenoides*
Carex pennsylvanica (?)	*Phacelia idahoensis* (?)
Carex sp.	*Phlox hoodii*
Castilleja linariaefolia	*Phlox longifolia*
Cercocarpus montanus	*Physaria floribunda*
Chrysothamnus nauseosus	*Poa fendleriana*
Chrysothamnus viscidiflorus	*Pinus edulis* (sapling)

Table 4. (Continued)

Purshia tridentata	*Taraxacum officinale*
Quercus gambelii	*Tetradymia canescens*
Rhus trilobata	*Townsendia hookeri*
Senecio sp.	*Tragopogon dubius*
Sitanion longifolium	*Yucca glauca*
Sphaeralcea coccinea	*Zygadenus venenosus*
Symphoricarpos oreophilus	*Senecio multilobatus*

Table 5. SPECIES OBSERVED IN THE RIDGETOP SAGEBRUSH COMMUNITY (DRILLING SITES 6, 10, 16, AND THE AQUIFER TEST SITE)

Agoseris glauca	*Juniperus osteosperma* (sapling)
Agropyron smithii	*Lomatium* sp. (?)
Antennaria parvifolia	*Lupinus* sp.
Arabis sp.	*Malcolmia africana*
Artemisia tridentata	*Phlox hoodii*
Calochortus sp.	*Phlox longifolia*
Carex sp.	*Pinus edulis* (sapling)
Castilleja linariaefolia	*Poa fendleriana*
Chrysothamnus nauseosus	*Poa* sp.
Chrysothamnus viscidiflorus	*Sphaeralcea coccinea*
Delphinium nelsoni	*Stipa comata*
Erigeron sp.	*Trifolium gymnocarpon*

Table 6. SPECIES OBSERVED IN THE VALLEY FLOOR SAGEBRUSH COMMUNITY (DRILLING SITES 1 AND 4)

Agropyron smithii	*Eurotia lanata*
Artemisia frigida	*Lappula redowskii*
Artemisia tridentata	*Lepidium montanum*
Bouteloua gracilis	*Phlox longifolia*
Bromus tectorum	*Physaria floribunda*
Chrysothamnus viscidiflorus	*Sisymbrium altissimum*
Chrysothamnus nauseosus	*Sphaeralcea coccinea*
Descurainia pinnata	*Taraxacum officinale*

Table 7. SPECIES OBSERVED IN A VALLEY FLOOR PASTURE (DRILLING SITE 8)

Artemisia dracunculus	*Chrysothamnus nauseosus*
Artemisia frigida	*Delphinium nelsoni*
Artemisia tridentata	*Grindelia squarrosa*
Astragalus sp.	*Lappula redowskii*
Bouteloua gracilis	*Lepidium perfoliatum*
Bromus tectorum	*Sisymbrium altissimum*

Table 8. DEER PELLET COUNTS

Drill Site	No. of Pellet Groups
5	23
6	5
11	21
14	12
15	15
17	30

Note: Clusters of deer pellets were counted in twelve randomly located quadrats (20x20 ft) on each of six drill site locations. Numbers of pellet groups suggest extent of habitat utilization.

Elk droppings were observed at three locations: near drill sites 4, 9, and 14.

Table 9. SPECIES OF BIRDS AND MAMMALS IDENTIFIED FROM MAY 13 THROUGH MAY 15, 1974, ON TRACT C-b (Species listed in phylogenetic order)

Birds observed below 6500 ft	Birds observed above 6500 ft
mallard	red-tailed hawk
golden eagle	swainson's hawk
raven	turkey vulture
magpie	sparrow hawk
mourning dove	goshawk hawk
white-throated swift	red-shafted flicker
violet-green swallow	raven
rough-winged swallow	pinyon jay
cliff swallow	clark's nutcracker
barn swallow	mourning dove
western kingbird	sage thrasher
empidonax flycatcher	robin
myarcus flycatcher	mountain bluebird
hummingbird (?)	green-tailed towhee
brewer's blackbird	
red-winged blackbird	
robin	
mountain bluebird	
green-tailed towhee	

Mammals observed below 6500 ft	Mammals observed above 6500 ft
yellow-bellied marmot	coyote
pocket gopher *(T. talpoides?)*	golden-mantled ground squirrel
muskrat	chipmunk *(E. minimus?)*
mule deer	pocket gopher *(T. talpoides?)*
	woodrat *(N. cinerea?)*
	cottontail *(S. nuttallii?)*
	elk
	mule deer

Table 10. WATER QUALITY FOR TRACT C-b DRAINAGE

Station	Depth (in.)	Width (ft)	Temp. (^{o}F)	pH	Total alkalinity (mg/ℓ)	CO_2 (mg/ℓ)	Specific cond. (μMIOS/cm)	Dissolved Oxygen (mg/ℓ)	Total Hardness (mg/ℓ)	Total Iron (mg/ℓ)	Ammonia Nitrogen (N) (mg/ℓ)	Nitrate as N (mg/ℓ)	Nitrite as N (mg/ℓ)	Ortho-Phosphate as (PO_4) (mg/ℓ)	Turbidity (FTU)	Date (1974)
P-1	13	12	58	9.3	475	0.0	980	9.0	310	0.8	0.1	6.0	0	1.1	430	5/12
P-3	12	15	52	9.2	370	28	950	9.0	310	0.7	0.6	3.0	0	1.1	160	5/13
P-6	15	15	48	9.2	460	0.0	1230	9.0	390	0.4	0.1	6.0	0	0.6	110	5/13
W-1	6	2	47	9.2	450	0	1340	7.0	570	0.0	0.8	0.8	0	0.6	15	5/14
W-3	4	2	52	9.2	490	68	1450	6.0	730	0.1	0.7	0.7	0	7.2	10	5/13
S-1	3	5	63	9.1	440	56	1400	7.0	515	0.2	1.1	2.5	0	1.2	40	5/14

Table 11. SUMMARY OF BENTHIC INVERTEBRATE COLLECTIONS FROM TRACT C-b DRAINAGE

	Sampling Stations										Totals
	P-1	P-2	P-3	P-4	P-5	P-6	W-1	W-2	W-3	S-1	
Plecoptera (Stoneflies)	44	2	89	24	14	116	23	275	9	2	598
Epheroptera (Mayflies)	237	39	257	307	147	587	249	431	122	12	2388
Trichoptera (Caddis flies)	466	11	618	234	76	83	20	2			1510
Diptera (True flies)	36	6	25	9	27	11	12	25	79	12	242
Odonata (Dragonflies & Damselflies)	1			1				5			7
Coleoptera (Beetles)	6		12	37	5	14		14			88
Hemiptera (True bugs)	1						4	1		1	7
Amphipoda (Scuds)					1		6	119	1		127
Annelida (Worms, Leeches & Polychaetes)		3		1				5	1		10
Gastropoda (Snails)					1			10	11		22
											4999

Table 12. SUMMARY OF FISH COLLECTIONS FROM TRACT C-b DRAINAGE

Station	Species[a]	Number Collected	Range in Length (mm)	Average Length (mm)
P-1	R.T.	1		525.0
	Brk. T.	6	184-288	246.0
	B.S.	3	86-90	89.0
	S.D.	2	54-69	61.5
P-2	Brk. T.	6	180-309	272.0
	B.S.	5	87-160	129.0
	S.D.	1		63.0
P-3	Brk. T.	3	203-290	239.0
	B.S.	11	70-133	90.0
	S.D.	11	60-98	71.0
P-4	Brk. T.	2	295-329	312.0
	B.T.	1		170.0
	B.S.	7	69-152	98.0
	S.D.	4	66-68	67.0
P-5	B.S.	4	71-136	89.5
	S.D.	1		64.0

Table 12 (Continued)

Station	Species[a]	Number Collected	Range in Length (mm)	Average Length (mm)
P-6	Brk. T.	2	311-375	343.0
	B.T.	1		208.0
	B.S.	21	69-141	94.0
	S.D.	11	62-86	69.0
W-2	B.S.	2	112-117	115.0
S-1	B.S.	3	79-90	85.0
	Trout Larvae	1		

[a]Species Legend:

Rainbow Trout (R.T.) *Salmo gairdneri*
Brown Trout (B.T.) *Salmo trutia*
Brook Trout (Brk. T.) *Salvelinus fontinalis*
Bluehead Sucker (B.S.) *Catostomus discobolus*
Speckled Dace (S.D.) *Rhinichthys osculus*

Table 13. PRESENCE OF PERIPHYTON IN STREAMS ADJACENT TO TRACT C-b, PICEANCE BASIN (COLORADO)

Taxon	STATION S-1	P-1	P-3	P-6	W-1	W-3
Bacillariophyceae						
(Diatoms)						
Meridion sp.				x	x	x
Nitzchia sp.	x	x	x	x	x	x
Diatoma sp.					x	x
Navicula sp.	x	x	x	x	x	x
Fragilaria sp.	x	x	x	x	x	x
Tabilaria sp.	x			x	x	x
Synedra sp.	x	x	x	x		
Cymbella sp.		x	x	x		
Chlorophyta						
(Green algae)						
Spirogyra sp.	x		x	x		x
Cyanophyta						
(Blue-green algae)						
Oscillatoria sp.	x		x	x		x
Trachaeta						
(Vascular plants)						
Salvinia sp.					x	x
Lemna sp.	x					
Nasturtium sp.					x	x

S = Stewart Creek; P = Piceance Creek; W = Willow Creek

Appendix A

RESUMES OF RECONNAISSANCE TEAM

Joe M. Merino

terrestrial and
aquatic ecology;

Education

University of California, Riverside and California State University, San Diego: Doctoral Candidate, Ecology
Duke University: Marine Ecology
University of Wisconsin: Limnology
Brigham Young University: M.S. Zoology, 1967
Brigham Young University: B.A. Zoology, 1961

Professional history

Woodward-Envicon, Inc., San Diego, Ecologist, 1971-date.
Brigham Young University, Animal Ecologist, Center for Environmental Studies, June 1971 – September 1971.
Environmental Engineering Laboratory, San Diego, Consultant in Biology, 1969-71.
University of California, San Diego Medical School, Research in Cardiac Dynamics, 1969-70.
University of Wisconsin, Milwaukee, Laboratory assistant in General Zoology, 1967-69.
University of Wisconsin, Milwaukee, Project Assistant, Center for Great Lakes Studies, June 1968 – September 1968.
University of Wisconsin, Milwaukee, Graduate Advisor to NSF recipients, May 1968 – August 1968.
Brigham Young University, Zoology Department, AEC/BYU Ecology Project, 1965-67.
Brigham Young University, Zoology Department, Research assistant, 1959-61 and 1964-67.
Bureau of Commercial Fisheries, La Jolla, California, correlated fisheries to environmental conditions, 1958-59.

Representative projects

Research assistant for the AEC/BYU Ecology Project at Mercury, Nevada delineating desert plant and animal communities. Project assistant studying effects of harbor sediments on planktonic and benthic plant and animal species from the Great Lakes for Army Corps of Engineers. Consulting biologist on projects relating to discharge of power plant cooling water into San Diego Bay, San Diego; Los Angeles–Long Beach Harbor, Los Angeles, California; and into the Pacific Ocean at Carlsbad, California. Contributed to both terrestrial and aquatic environmental studies as an ecologist in Colorado, Utah, Arizona, and California for the Denver Water Board, the Navajo Project, and the LaJolla Beach and Tennis Club.

Honors

National Defense Education Act, Fellowship, 1971-72.
Center for Great Lakes Studies, Fellowship, 1967-69.
National Science Foundation, Fellowship, 1967.

Affiliations

Western Society for Malacologists, 1972.
Southern California Academy of Sciences, 1971.

Publications

"A Study of the Effects of Water Discharge to South San Diego Bay from the Clair Engle Desalting Plant". With R. L. Chambers. Technical Report SD-9-73, 1972.

"Ecological effects of power station cooling water discharge in South San Diego Bay during February—March 1971". With R. L. Chambers and R. F. Ford. Technical Report P.O. No. C-821, 1971.

"Ecological effects of power station cooling water discharge in South San Diego Bay during August 1970". With R. L. Chambers and R. F. Ford. Technical Report P.O. No. C-821, 1970.

"Food and Color Preference in the House Sparrow (Passer domesticus)." Manuscript in preparation.

"Notes on the Biology of Dissodactylus calmani Rathbun 1918 (Decapoda-Pinnotheridae)." Manuscript in preparation.

"Biological Observations on the Scorpions of a Grassland Community in Southern Utah." Manuscript in preparation.

"Notes on Dissodactylus borradailei Rathbun 1918 (Decapoda-Pinnotheridae), a Commensal on the Heart Urchin, Meoma ventricosa L." Submitted to Crustaceana.

"Ticks of the Genus Haemaphysalis in the Western United States." (BYU Zoology and Entomology), Thesis for M.S. Degree.

JMM 6/73

RESUME

Warren R. Keammerer

Born: November 25, 1946

Present Position: Research Ecologist - Stoecker-Keammerer & Assoc. Ecological Consultants

Education:

Capital University 1964-1968
Columbus, Ohio B.S. cum laude

North Dakota State University 1968-1972
Fargo, North Dakota Ph.D. 1972
(Plant Ecology)

Awards and Scholarships:

Student Participant, The American Museum of Natural History -- NSF Undergraduate Research Program at the Kalbfleisch Field Research Station, Suffolk County, New York.
Summers 1967 and 1968

National Defense Education Act Fellowship at North Dakota State University 1968-1971

Professional Affiliations:

Ecological Society of America
The British Ecological Society
The Society of the Sigma Xi
American Institute of Biological Sciences
The Wilderness Society
The Nature Conservancy

Research History:

Summers 1967 and 1968. NSF student participant in vegetation studies at the Kalbfleisch Field Research Station. The research projects were designed for study of old field succession, forest ecology, pattern analysis, the effects of fire on old fields and forest understory, and the effects of selective application of sylvicide on succession in old fields.

1968-1971. Thesis research project which was designed to determine the structure and composition of forests along the Missouri River in North Dakota. Through ordination and gradient analysis techniques, relationships between plant species, communities, and environmental parameters were determined.

1972-1973. Post-doctoral research fellowship at the University of Colorado, Institute of Arctic and Alpine Research. Research work

focused on the anticipated environmental impacts resulting from a winter cloud seeding program in the San Juan Mountains of Colorado.

1973-Present. Ecological Consultant to various companies including:

Atlantic Richfield Company
Colony Development Operation
Cornell Howland, Hays & Merryfield,
Clair A. Hill & Associates
Colorado Public Service Company

Most of my recent research work has been conducted in the oil shale region of west-central Colorado. The studies have been designed to provide baseline ecological data for the regional vegetation which can be used in prediction of environmental impacts resulting from development of the oil shale resource.

Teaching Experience:

1964-1968. Undergraduate laboratory assistant in ecology, general biology, and vertebrate morphology.

1968-1971. Laboratory instructor in general biology, general botany, plant ecology, and plant systematics.

1971-1972. Lecturer in Biology at Capital University, Columbus, Ohio - Introductory biology, general ecology, and general botany.

1973. Lecturer in Biology at the University of Colorado, Boulder - Advanced classification of flowering plants.

Publications:

Keammerer, W. R. and W. C. Johnson. 1970. The vegetation of the Missouri River floodplain forests. Proc. of the N. D. Acad. Sci. 24(I), abstracts.

Keammerer, W. R. 1972. The understory vegetation of the bottomland forests of the Missouri River in North Dakota. Ph.D. thesis, North Dakota State University, Fargo. 234p.

Keammerer, W. R. and P. J. Webber (compilers). 1973. The vegetation continuum: a collection of readings. Manuscript.

Keammerer, W. R. 1974. Sullivantia purpusii and Astragalus lutosus in Garfield County, Colorado. Pro. of Colo.-Wyo. Acad. Sci. (Abstract)

Keammerer, W. R., W. C. Johnson, and R. L. Burgess. 1974. Floristic analysis of the Missouri River bottomland forests in North Dakota. Submitted to the American Midland Naturalist.

Burgess, R. L., W. C. Johnson, and W. R. Keammerer. 1973. Vegetation of the Missouri River floodplain in North Dakota. Research Project Technical Completion Report #WI-221-018-73. North Dakota Water Resources Research Institute, Fargo. 162p.

Johnson, W. C., R. L. Burgess, and W. R. Keammerer. 1974. Forest overstory vegetation on the Missouri floodplain in North Dakota. Submitted to Ecological Monographs.

Consulting Reports:

Keammerer, W. R. 1974. The vegetation of Parachute Creek Valley. Report to Colony Development Operation, Denver, Colorado.

Keammerer, W. R. 1974. The ve etation of the Grand Valley Area. Report to Colony Development Operation, Denver, Colorado.

Keammerer, W. R. and R. E. Stoecker. 1974. Preliminary report on the vegetation and wildlife of Colorado oil shale tract C-b. Report to Woodward-Envicon, Inc., San Diego, Cal.

Stoecker, R. E. and W. R. Keammerer. 1974. Powerline environmental analysis of Parachute Creek Valley. Report to Public Service Company of Colorado.

Stoecker, R. E. and W. R. Keammerer. 1974. The ecology of Boulder Creek: environmental inventory and evaluation of sewage treatment alternatives. Report to Cornell, Howland, Hayes, & Merryfield; Clair A. Hill & Associates, Denver, Colorado. 51p.

CURRICULUM VITAE

Robert E. Stoecker, Ph.D.
Animal Ecologist

Stoecker- Keammerer & Assoc.
Ecological Consultants
395 30th Street
Boulder, Colorado 80303

Phone: (303) 443-9647
or (303) 494-7642

Education:

1960-61 - University of Missouri Resident Center, St. Louis, Missouri.
1961-62 - Washington University, St. Louis, Missouri.
1962-65 - University of Missouri, Columbia, Missouri B.A. Degree 1965.
1965-67 - Montana State University, Bozeman, Montana M.S. Degree 1967.
1967-70 - University of Colorado, Boulder, Colorado Ph.D. Degree 1970.

Teaching Experience:

Animal Ecology 443 - 1972, University of Colorado, Boulder, 4 credit course.
Biology 100 - 1972, University of Colorado, Boulder.

Present University Affiliation:

Professor Adjoint - Department of Biology, University of Colorado, Boulder.

Research Interests:

Predator-prey relations
Hunting and kill behavior among mammalian and avian predators
Competitive exclusion
Alpine ecology
Social structures of mammalian populations

Consultant Experience:

1970-71 Industrial Bio-Test Laboratories, Inc., Northbrook, Illinois - Environmental impact analysis of proposed nuclear power plants on terrestrial fauna.

1971-74 Bureau of Reclamation - Environmental impact of weather modification on alpine fauna.

Consultant Experience (continued)

1972 Army Corps of Engineers - Analysis of terrestrial fauna in relation to flood control on Boulder Creek, Boulder, Colorado.

1972 Flatirons Sand and Gravel Co. - Fauna of the White Rocks vicinity. Boulder, Colorado. 20 p.

1973-74 Geoecology Associates, Boulder, Colorado - Environmental impact of community development along the Colorado River near Grand Valley, Colorado.

1973-74 Geoecology Associates, Boulder, Colorado - Environmental impact of a proposed utilities corridor along Parachute Creek, Garfield County, Colorado.

1973-74 Atlantic Richfield Co. - Preparation of final impact statement on proposed oil shale mining operation in the Piceance Basin near Grand Valley, Colorado.

1974 Public Service Company of Colorado, Denver, Colorado - Powerline environmental analysis of Parachute Creek Valley.

1974 CH_2M Hill Associates - The Ecology of Boulder Creek: environmental inventory and evaluation of sewage treatment alternatives. Boulder, Colorado. 51 p.

Publications:

Stoecker, R.E. and C.E. Bock. 1971. The effects of weather modification on animals in the alpine tundra. The San Juan Ecology Project. Colorado State University, Department of Watershed Sciences, pp. 191-219.

Stoecker, R.E. 1972. Animal distributions in relation to snow in alpine tundra. The San Juan Ecology Project. Colorado State University, Department of Watershed Sciences, pp. 66-74.

Stoecker, R.E. 1972. Competitive relations between sympatric populations of voles (*Microtus montanus* and *M. pennsylvanicus*). Journal of Animal Ecology 41: 311-329.

Stoecker, R.E. 1974. Coyote predation on sheep in northwestern Colorado. Journal of Colorado-Wyoming Academy of Science.

Publications (continued)

Stoecker, R.E. and N. Cain. (in progress). Biogeomorphic relationships of pocket gophers (*Thomomys talpoides*) in alpine tundra. Journal of Arctic and Alpine Research.

Stoecker, R.E. (in progress). Kill technique of the African silver-backed jackal (*Canis mesomelas*). Journal of Mammology.

Stoecker, R.E. (in progress). Tracks of Mammals of the United States. Western Publishing Company, New York.

Walter R. Odening

terrestrial ecology;
botany; zoology

Education

Duke University: Ph.D. Botany, 1971
University of California, Riverside: Biology.
San Diego State University: M.S. Biology, 1968.
San Diego State University: B.S. Biology, 1963.

Professional history

Woodward-Envicon, Inc., San Diego, California, Staff Scientist, 1973-date.
Environmental Consultant, 1972-73.
Grossmont College, El Cajon, California, Biology Instructor, 1973.
University of Michigan, Assistant Professor of Resource Ecology, 1971-72.
Duke University, Durham, North Carolina, Postdoctoral Research Associate, 1970-71.
Duke University, Durham, North Carolina, Research Assistant, 1969-70.
University of California, Riverside, California, Teaching Assistant, Biology, 1968.
San Diego State University, San Diego, California, Teaching Assistant, Biology and Zoology, 1965-67.
San Diego State University, San Diego, California, Research Assistant, 1964-67.
U.S. Food and Drug Administration, Los Angeles District, Inspector, 1963-64.
U.S. Navy, Engineering Aide, Surveyor II, 1959-61.

Representative projects

Dr. Odening has conducted a variety of environmental programs concerned with terrestrial ecology. In addition to major contributions on environmental impact studies for water supply and land development projects in southern California, he has conducted specific studies in ecology in the transverse and peninsular ranges of that area and in the White Mountains of the central California area. He has also participated in ecological studies of the deciduous forest biome and desert areas. The desert studies emphasized the physiology and taxonomy of desert shrubs.

Honors

Biomedical Sciences, Support Grant Research Traineeship, Duke University, 1970.

Affiliations

Ecological Society of America.
American Association for the Advancement of Science.
American Society of Plant Physiologists.
American Institute of Biological Science.
San Diego County, Off-Road Vehicle Advisory Committee.

Publications

"Tissue Water Potential, Photosynthesis, ^{14}C Labeled Photosynthate Utilization and Growth in the Desert Shrub Larrea divaricata *cav.," Oechel, W.C., B.R. Strain and W.R. Odening, Ecological Monographs 42 (2) 127-141, 1972.*

"Photosynthesis Rates of a Desert Shrub Larrea divaricata *cav. under Field Conditions," Oechel, W.C., B.R. Strain and W.R. Odening,* Photosynthetica *6 (2) 183-188, 1972.*

"The Effects of Decreasing Water Potential on Net CO_2 Exchange of Intact Desert Shrubs," Odening, W.R., B.R. Strain and W.C. Oechel, accepted by Ecology *(currently under revision).*

"Negative Pressure Potentials in Larrea divaricata *cav. and Their Possible Ecological Significance," Odening, W.R., B.R. Strain and W.C. Oechel. Presented to AAAS 1971, Abstract published in* Bulletin of Ecological Society of America, *1971.*

"The Effects of Transitory and Extended Periods of Cloud Cover on Net CO_2 Exchange in Loblolly Pine," Odening, W.R., J. Mulroy and B.R. Strain. Presented to AAAS 1971, Abstract published in Bulletin of Ecological Society of America, *1971.*

"Light Acclimation Potential in Loblolly Pine," Odening, W.R., J. Mulroy and B.R. Strain, Photosynthetica.

"Negative Pressure Potentials (Turgor Pressures) in the Creosote Bush Larrea divaricata *cav.," Odening, W.R., B.R. Strain and W.C. Oechel,* Canadian J. of Botany.

Steven J. Puttmann

biology

Education

Colorado State University: M.S. Fishery Biology, 1973.
Colorado State University: B.S. Fishery Biology, 1971.

Professional history

Woodward-Envicon, Inc., Fisheries Biologist, 1973-date.
Colorado State University, Graduate Research Assistant, 1971-73.
Alaska Department of Fish and Game, Fishery Technician, 1969, 1970.

Representative projects

Mr. Puttmann was involved in graduate research for the Colorado Division of Wildlife on artificial propagation and management of the walleye in eastern Colorado irrigation impoundments, and on artificial diet training for smallmouth bass. In addition, he participated in several environmental impact analyses. The analyses evaluated the Eagle-Piney Water Diversion Project in Colorado and the Homestake Reservoir Extension Project, and the Gulf-Interstate Natural Gas Pipeline Project in Oregon, Nevada and California. On the Eagle-Piney Project, his work involved inventories of benthic invertebrates and analysis of fish population density and diversity. The inventories focused on dam sites and tributary streams for several diversion configurations. Final reports were submitted for impact analysis. The Homestake Extension activity included inventories of benthic invertebrates and fish population density and diversity for major tributaries of the Homestake watershed. A dam site had been proposed to supply additional water to the cities of Colorado Springs and Aurora. His work on the Gulf-Interstate pipeline involved a thorough literature review, compilation of the data available, and preparation of the environmental impact reports for the sections of the pipeline in lower Oregon, Nevada, and California.

Affiliations

American Fisheries Society.
American Association for Advancement of Science.
Trout Unlimited.
Bass Anglers Sportsman Society.

Publications

"Artificial Diet Training for Smallmouth Bass," M.S. Thesis, Colorado State University, 1973.

Robin F. Knox

fisheries biology;
thermal effects studies

Education

University of Missouri: M.A. Fisheries, 1973.
University of Illinois: B.S. Zoology, 1968.

Professional history

Woodward-Envicon, Inc., Fisheries Biologist, 1973-date.
U.S. Army, Walter Reed Army Medical Center, Walter Reed Army Institute of Research, Biological Sciences Technician, 1969-71.

Representative projects

Mr. Knox conducted qualitative sampling of fish and aquatic invertebrates as part of an environmental impact study for a proposed water diversion plan in the Homestake Creek region of the upper Colorado River drainage basin.

Previous experience includes qualitative sampling of zooplankton, aquatic invertebrates, and fish in a steam-electric plant cooling reservoir on the Middle Fork of the Chariton River, Missouri. Graduate research on this reservoir included quantitative studies of the effects of thermal additions on the levels of lipid in various tissues, and the reproductive organs of the white crappie. Graduate field work included quantitative methods of benthos and plankton sampling, stomach analysis and collection of fishes.

Additional experience involved sampling of fish and invertebrates along the Atlantic Coast near the Indian River Inlet, Delaware, under the auspices of the U.S. Department of Agriculture graduate school; and sampling of fish and invertebrates in the Florida Keys region under the direction of the Department of Zoology, University of Illinois.

Affiliations

American Fisheries Society.
Georgia Professional Fisheries Workers Association.

Publications

"Alteration of Lipid Content of Tissues and Gonosomatic Indices of White Crappie by Thermal Additions in Thomas Hill Reservoir, Missouri," 1973.

"Evaluation of Environmental Alterations by Thermal Loading and Acid Pollution in the Cooling Reservoir of a Steam Electric Station," 1970.

William D. Clark

biology

Education

Colorado State University: B.S. Fishery Biology, 1971.

Professional history

Woodward-Envicon, Inc., Atlanta, Georgia, Fisheries Biologist, 1973-date.
National Fish Hatchery, Leadville, Colorado, Fish Hatchery Technician, 1972-73.
Peace Corps Training, University of Oklahoma Research Institute, Peace Corps Trainee, 1971.
Vermont Fish & Game Department, Swanton, Vermont, Biology Aide, 1970.

Representative projects

Mr. Clark was involved in the qualitative analysis of fish and aquatic invertebrates of the Homestake drainage basin in the Upper Colorado River basin, Redcliff, Colorado. Prior to that, he was associated with the chemical treatment of rainbow trout diseases and hatching of wild lake trout eggs at the National Fish Hatchery, Leadville, Colorado. Mr. Clark also received field training for intensive culture of carp for the Peace Corps, including field collection of wild fish in Lake Texohma on the Red River. He had also been involved in the field collection of a representative cross section of fish for mercury contamination studies in Lake Champlain and the drainages of the Lamoille, Mississquoi, and Winooski rivers for the Vermont Fish and Game Department.

Affiliations

National Wildlife Federation.

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(June 1984)

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